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1984/03

TR-FL-1
NRC No. 23408

ANALYSIS OF "CAPTAIN SCOTT'S ANTARCTIC EXPEDITION 1910 SHELL MOTOR SPIRIT"

L. Gardner, B. Glavincevski, G. Moon, D. McDill

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ANALYSIS OF "CAPTAIN SCOTT'S ANTARCTIC EXPEDITION 1910 SHELL MOTOR SPIRIT"

Analyses de "carburant auto Shell provenant de l'expédition de 1910 du Capitaine Scott en Antartique".

L. Gardner, B.Glavincevski, G. Moon, D. McDill

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ABSTRACT

A sample of motor gasoline taken from a recently discovered fuel dump in the Antarctica has been analyzed by various techniques to define its hydrocarbon composition. This gasoline is a part of the fuel supplies laid down for Captain Scott's last expedition in 1910-1912.

RÉSUMÉ

Un échantillon d'essence pour moteurs prélevé d'un dépôt de combustible découvert récemment dans l'Antarctique a été analysé au moyen de diverses techniques afin de déterminer sa composition en hydrocarbures. Cette essence fait partie des approvisionnements de combustible déposés pour la dernière du Capitaine Scott en 1910-1912.

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ANALYSIS OF "CAPTAIN SCOTT'S ANTARCTIC EXPEDITION 1910 SHELL MOTOR SPIRIT"

1.0 INTRODUCTION

A sample of motor gasoline taken from a fuel dump near Camp Evans, Ross Island, Antarctica and identified as "Captain Scott's Antarctic Expedition 1910 Shell Motor Spirit" has been submitted to the National Research Council, Fuels and Lubricants Laboratory for analysis. The sample was taken by Mr. G.J. Dougherty of the Department of Scientific Research (DSIR) Lower Hutt, New Zealand during a visit to Ross Island in December 1982 and is part of the fuel supply used by Captain Scott during the last expedition of 1910-1912.

The gasoline was received in two small glass vials packed in a plastic (polyurethane) liner. On receipt some deterioration of the plastic in the vicinity of the vial caps was noted and this was attributed to some vapour loss during shipment.

2.0 IDENTIFICATION OF SAMPLE

NRC Sample Number	Description
FLO 83224	"Captain Scott's Antarctic Expedition 1910 Motor Spirit". Approximately 15mL received in two glass vials.

3.0 ANALYTICAL PROCEDURES AND INSTRUMENTATION

Sample FLO83224 was analyzed using the following procedures:-

(a) ASTM D1319, FIA Analysis
(b) Gas Chromatography
(c) Gas Chromatography/Mass Spectrometry
(d) Proton Nuclear Magnetic Resonance

3.1 ASTM Method D1319

ASTM Method D1319 (Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption) is used to measure saturates, nonaromatic olefins and aromatics in fuels and is widely used in specifications where hydrocarbon type limits are used.

3.2 GAS CHROMATOGRAPHY

The sample was analyzed using gas chromatographic methods for simulated distillation and PNA (paraffins, naphthenes and aromatics) analysis.

3.2.1 Simulated Distillation

The simulated distillation was performed according to ASTM D2887-Standard Method for Boiling Range Distribution of Petroleum

Fractions by Gas Chromatography. The software for this method was developed by Varian for the Varian Vista 401 interfaced to an Apple II Computer.

3.2.1.1 Instrumentation

The instruments used were a Varian Vista 4600 Gas Chromatograph equipped with dual flame ionization detectors connected to a Varian Vista 401 data handling system interfaced to an Apple II computer.

Dual six foot columns of 1/8" O.D. stainless steel packed with 10% UC W-98 on chromosorb W-HP, 80/100 mesh were used for the analysis.

3.2.1.2 Operating conditions

Initial Oven Temperature	-30°C
Final Oven Temperature	250°C
Programming Rate	8°C/min
Detector Type	Dual F.I.D.
Carrier Gas	Helium (40mL/min)
Detector Fuel Gas	Hydrogen (25mL/min)
Detector Support Gas	Air (300mL/min)
Detector Temperature	280°C
Inlet Port Temperature	280°C
Sample Size	0.5µL

3.2.2 PNA Analysis

The concentration of paraffins, naphthenes and aromatics in the sample were determined using a gas chromatographic system for PNA analysis. (Option 850 developed by Hewlett Packard).

3.2.2.1 Instrumentation

The instrument used was a Hewlett Packard 5880A Level 4 Gas Chromatograph equipped with a flame ionization detector and a Hewlett Packard Model 7671A Automatic Sampler.

The column used was a 50m fused silica capillary column (0.20mm I.D.) coated with cross-linked methyl silicone (0.50µm film thickness).

3.2.2.2 Operating Conditions

Oven temperature profile	35°C
Initial Hold Time	15 min
Level 1	
Programming Rate	1.50°C/min
Final Value	70°C
Final Time	0.00

Level 2	
Programming Rate	3.00°C/min
Final Value	130°C
Final Time	21.67 min
Level 3	
Programming Rate	3.00°C/min
Final Value	290°C
Final Time	17.00 min
Detector Type	F.I.D.
Detector Fuel Gas	Hydrogen (2.6mL/min)
Detector Support Gas	Air (400mL/min)
Detector Temperature	300°C
Inlet Port Temperature	300°C
Carrier Gas	Helium
Column Head Pressure	29.5 p.s.i.g.(203kPa)
Capillary Inlet System Mode	Split
Split Flow	200mL/min
Make-up Gas Flow	28mL/min
Sample Size injected	1µL

The operating conditions were set according to the procedure outlined in the Hewlett-Packard PNA and 5880A manuals except that level 3 of the oven temperature profile was added in order to determine if there were any components in the sample outside the range of the PNA program (80 min, 130°C). Also the inlet port temperature was increased for 250°C to 300°C.

3.3 Gas Chromatography - Mass Spectrometry

The spectra were recorded on a Finnigan Model 1020B/OWA quadrupole mass spectrometer equipped with a standard EI source. Ionization was accomplished by using a source voltage of 70eV, manifold temperature 80°C and electron multiplier voltage of 1800V. The sample was introduced by means of a Perkin-Elmer Sigma 3B Gas Chromatograph directly interfaced to the mass spectrometer by OV-101 vitrious silica WCOT capillary column (50m x 0.20 mm i.d.). Typical gas chromatographic conditions included injector temperature 250°C, interface 255°C and column temperature program from 25 to 245°C with 4°C/min after the initial temperature had been held for 15 min. Masses from 40 to 300 mass units were scanned every second. The concentration of the substances was determined by utilizing the ion current of the enhanced spectrum of each peak, excluding the current of interfering mass ions.

3.4 Proton Nuclear Magnetic Resonance

The ^{1}H NMR spectrum of the gasoline was recorded on a Varian EM-360 spectrometer operating at 60 MHz at room temperature. Chloroform-d, (99.9%) with 1% TMS was used as solvent. Concentration of 50/50 by volume of sample to solvent was used for recording the spectrum.

4.0 Results

The obtained results by the various techniques are presented in the following Tables:-

Table 1: Simulated Distillation Analysis Report
Table 2: PNA Program Printout: Component Identification and Concentration.
Table 3: PNA Program Printout: Hydrocarbon Type and Carbon Number Distribution.
Table 4: Hydrocarbon Distribution by Group Type and Carbon Number (Derived from Table 2).
Table 5: Comparison of GC/MS, ^{1}HNMR, GC and FIA Data

Supporting information (chromatographic printouts) is presented in Appendix A and B:

Appendix A
Table A-1: Simulated Distillation Calibration Report
Appendix B
Table B-1: PNA Program, Chromatographic Data

5.0 Discussion of Results

(a) The simulated distillation initial boiling point of 2°C is approximately 20°C higher than current (Canadian) gasolines. It is not known if this is due to any loss of light ends during shipment (see Introduction), since the sample still contains a significant amount of C_4 and C_5 paraffins. The boiling range of the sample is also much narrower than current gasolines.

It should be noted that simulated distillation values more closely represent true boiling points distribution and can only be compared with D-86 results by a correlative program.

(b) The results presented in Table 5 show good agreement was obtained amongst the methods used to measure hydrocarbon type composition.

(c) The PNA chromatogram and chromatographic data (Table B-1) show that in excess of 140 peaks were detected in the sample analysis. Of these peaks 124 were assigned an identification by the PNA program solely on the basis of retention time. The accuracy of the identification in a complex hydrocarbon mixture such as a gasoline, where a large number of components with retention times of close proximity exist, has not yet been established. This should be taken into account when reviewing the PNA data in particular for trace components with similar retention times to other components.

(d) The data extracted from Table 2 and presented in Table 4 can be summarized as follows:

n-alkanes

n-alkanes range from C_4-C_{11} (≈22% by wt) with the majority in C_5-C_8 range and a maximum at C_6 (≈7% by wt).

iso-alkanes

Iso-alkanes range from C_4-C_{11} (≈37% by wt) with majority in C_5-C_8 range and a maximum at C_6 (≈11% by wt). The iso-alkanes comprise homologous series of methyl, dimethyl and trimethyl alkanes the most predominant being 2-methyl and 3-methyl alkanes:-

2-Me butane (≈5% by wt)
2-Me pentane (≈6% by wt)
3-Me pentane (≈4% by wt)
3-Me heptane (≈4% by wt)
3-Me hexane (≈4% by wt)
2-Me hexane (≈4% by wt)
2-Me heptane (≈2% by wt)

cyclo-alkanes

Cycloalkanes display a maximum at C_7 (≈15% wt) with the most predominant compounds in the series being:-

Me cyclohexane	(≈10% by wt)
Me cyclopentane	(≈ 6% by wt)
cyclohexane	(≈ 4% by wt)
1,3-dimethylcyclopentanes	(≈ 3% by wt)
1,1-dimethylcyclopentane	(≈ 1% by wt)

Aromatics

The aromatics at (≈7% by wt) display a maximum at C_7 (≈ 4% by wt) with predominant compounds being:

Toluene	(≈ 4% by wt)
1,2-dimethylbenzene	(≈ 1% by wt)
benzene	(≈ 1% by wt)

6.0 Conclusion

Captain Scott's Shell motor spirit is as would be expected a relatively simple, straight run product consisting essentially of alkanes and cycloalkanes with a small quantity of aromatics.

TABLE 1: Simulated Distillation Analysis Report (FL083224)

Percent Off	B.P. °C
IBP	1.7
5	34.6
10	54.6
15	59.3
20	64.5
25	70
30	75.9
35	84.1
40	88.9
45	91.4
50	93.4
55	98.6
60	102
65	103.1
70	104.8
75	112.3
80	117.7
85	120.1
90	127.5
95	140.7
FBP	176.2

TABLE 2: PNA Program Printout: Component Identification and Concentration (FLO83224).

RT	COMPONENT	WT %	VOL %	SP GR
4.65	IC4	.318	.403	.5630
4.93	NC4	.915	1.118	.5840
5.07	22DMC3	.015	.018	.5970
5.95	IC5	5.170	5.901	.6250
6.51	NC5	4.956	5.604	.6310
7.55	22DMC4	.719	.784	.6540
8.66	CYC5	.867	.825	.7500
8.73	23DMC4	1.170	1.253	.6660
8.94	2MC5	5.622	6.096	.6580
9.65	3MC5	3.768	4.018	.6690
10.68	NC6	6.691	7.190	.6640
12.35	22DMC5	.499	.525	.6780
12.58	MCYC5	5.744	5.442	.7530
12.84	24DMC5	.619	.652	.6770
13.27	223TMC4	.135	.139	.6940
14.57	BZ	.895	.726	.8790
15.17	33DMC5	.297	.304	.6980
15.59	CYC6	3.886	3.541	.7830
16.65	2MC6	3.519	3.676	.6830
16.76	23DMC5	.852	.870	.6990
17.03	11DMCYC5	1.253	1.178	.7590
17.63	3MC6	3.548	3.664	.6910
18.25	T13DMCYC5	1.696	1.607	.7530
18.58	C13DMCYC5	1.537	1.456	.7530
19.07	224TMC5	.015	.015	.6960
20.64	NC7	5.964	6.184	.6880
23.10	MCYC6	10.405	9.591	.7740
23.37	22DMC6	1.174	1.200	.6980
24.38	ECYC5	.439	.406	.7710
24.89	25DMC6	.447	.446	.7140
25.58	CTC124TMCYC5	.806	.749	.7680
25.76	234TMC5	.236	.232	.7230
26.56	CTC123TMCYC5	.742	.683	.7750
26.93	233TMC5	.050	.049	.7300
27.52	TOL	3.620	2.979	.8670
28.60	2M3EC5	.045	.044	.7240
29.44	2MC7	2.060	2.094	.7020
29.59	4MC7	.601	.605	.7090
29.74	34DMC6	.132	.131	.7243
30.00	CCT124TMCYC5	.395	.088	.7680

TABLE 2: (continued)

30.52	3MC7	3.795	3.723	.7100
30.93	T14DMCYC6	.881	.819	.7670
31.47	11DMCYC6	.620	.563	.7850
31.86	C13DMCYC6	.044	.041	.7700
31.98	C1E2MCYC6	.149	.134	.7920
32.28	C1E3MCYC6	.129	.116	.7920
32.45	1MT3ECYC5	.241	.217	.7920
32.71	1E1MCYC5	.048	.044	.7920
33.13	T13DMCYC6	.744	.681	.7800
33.67	22C123TMCYC5	.012	.011	.7940
34.20	NC8	3.027	3.055	.7070
35.13	IC3CYC5	.064	.059	.7810
35.92	225TMC6	.056	.056	.7170
36.27	224TMC6	.028	.028	.7200
36.47	244TMC6	.024	.024	.7280
36.78	235TMC6	.160	.157	.7260
37.31	34 DMC7	.159	.159	.7130
37.60	24DMC7	.013	.013	.7140
38.04	NC3CYC5	.574	.524	.7810
38.27	ECYC6	.412	.382	.7710
38.78	113TMCYC6	.817	.744	.7830
39.12	25DMC7	.284	.284	.7140
39.32	33DMC7	.054	.054	.7140
39.61	24DMC7	.032	.032	.7140
39.80	233TMC6	.024	.023	.7410
40.37	ETBZ	.258	.211	.8720
40.72	114TMCYC6	.369	.340	.7760
41.21	334TMC6	.021	.020	.7480
41.53	MXYL	1.440	1.185	.8670
41.64	23DMC7	.634	.633	.7140
41.92	CTT124TMCYC6	.038	.035	.7760
42.01	CTC124TMCYC6	.033	.030	.7760
42.26	3MEC6	.052	.051	.7310
42.76	2MC8	.241	.239	.7170
43.09	C9-P	.037	.036	.7220
43.52	3MC8	.181	.178	.7240
44.05	OXYL	.317	.256	.8850
44.23	C9-P	.023	.022	.7220
44.73	1M2C3CYC5	.032	.029	.7560
44.87	T1E4MCYC6	.200	.180	.7930

TABLE 2: (continued)

45.09	C1E4MCYC6	.182	.164	.7930
45.52	CCC135TMCYC6	.005	.004	.7760
46.14	226TMC7	.033	.032	.7280
46.50	NC9	.576	.569	.7220
46.81	1M1ECYC6	.113	.101	.8040
47.09	C10-P	.037	.036	.7340
47.51	IC3BZ	.018	.015	.8660
47.87	TERTC4CYC5	.081	.072	.8060
48.06	TERTC4BZ	.017	.014	.8710
48.34	C10-P	.034	.033	.7340
48.49	C10-P	.035	.034	.7340
49.07	CCC123TMCYC6	.146	.135	.7760
49.40	IC4CYC5	.036	.032	.8030
49.93	3MC9	.031	.030	.7310
50.29	NC4CYC5	.065	.058	.8030
50.96	135TMBZ	.107	.088	.8700
51.14	M+P ETOL	.074	.060	.8850
51.65	C10-P	.153	.149	.7340
51.83	C10-P	.006	.005	.7340
52.44	O ETOL	.036	.029	.8850
52.72	22DMC8	.007	.007	.7280
52.98	36DMC8	.074	.072	.7280
53.73	124TMBZ	.085	.069	.8800
53.85	T1M2ECYC6	.025	.022	.7980
54.09	C10-P	.017	.017	.7340
54.79	1E23DMCYC6	.006	.005	.7980
54.96	C10-P	.009	.009	.7340
55.23	NC10	.096	.093	.7340
55.89	1M3IC3BZ	.031	.025	.8650
56.23	1M4IC3BZ	.002	.002	.8810
56.76	C11-P	.004	.004	.7440
57.05	1M2IC3BZ	.021	.017	.8620
57.43	SECC4CYC6	.010	.008	.8170
57.90	C11-P	.013	.012	.7440
58.17	NC4BZ	.012	.010	.8700
58.45	DEBZ	.009	.008	.8030
58.64	12DEBZ	.009	.008	.8030
59.24	IC4CYC6	.008	.007	.8170
59.72	5MC10	.008	.007	.7440
59.99	14DEBZ	.010	.008	.8800
60.20	C10-A	.008	.007	.8650
60.67	1M2C3BZ	.007	.005	.8810
62.70	NC11	.037	.036	.7440
72.36	PENTYL BZ	.007	.006	.8800

TABLE 3: PNA Program Printout: Hydrocarbon Type and Carbon Number Distribution (FL083224)

P N A A N A L Y S I S

++++++++++++++++++++++++++

SAMPLE:SCOTT 83224 BOTTLE#:1

SAMPLERINJECTION @15:53 DEC 7, 1983

HC TYPE	WT %	VOL %
TOTAL P	59.46	63.15
TOTAL N	33.55	31.12
TOTAL A	6.99	5.73
P3-5	11.37	13.04
P6	17.97	19.34
P7	15.43	16.01
P8	11.26	11.36
P9+	3.43	3.39
TOTAL P	59.46	63.15
N5	.87	.82
N6	9.63	8.98
N7	15.33	14.24
N8	5.31	4.89
N9+	2.41	2.19
TOTAL N	33.55	31.12
A6	.90	.73
A7	3.62	2.98
A8	2.02	1.65
A9+	.46	.37
TOTAL A	6.99	5.73

TABLE 4: Hydrocarbon Distribution by Group Type and Carbon Number

Type \ Cn	total wt %	4	5	6	7	8	9	10	11
n-alkanes	22.26	0.92	4.96	6.69	5.96	3.03	0.58	0.10	0.04
iso-alkanes	37.20	0.32	5.19	11.28	9.47	8.47	2.02	0.44	0.03
cycloalkanes	33.55		0.87	9.63	15.33	5.28	2.42	0.02	
aromatics	6.98	-	-	0.90	3.60	2.02	0.34	0.11	0.01

TABLE 5: Comparison of GC/MS, ^{1}H NMR, GC and FIA Data

Method		^{1}H NMR	GC		GC-MS	FIA
Hydrocarbon Type		vol%	vol%	wt %	wt %	vol
Aromatics		5.79	5.73	6.99	6.32	7.7
Paraffins	n-alkanes	94.21	23.85	22.26	22.33	91.8
	iso-alkanes		39.30	37.20	37.92	
	cycloalkanes		31.12	33.55	33.44	
Olefins		not observed	-	-	-	0.6

APPENDIX A

TABLE A-1 Simulated Distillation Calibration Report

PK#	Peak ID	B.P. °C	R.T.
1	C3	-42	.63
2	C4	0	1.62
3	C5	36	3.74
4	C6	69	6.39
5	C7	98	9.04
6	C8	126	11.51
7	C9	151	13.78
8	C10	174	15.9
9	C11	196	17.86
10	C12	216	19.71
11	C13	235	21.44
12	C14	253	23.08
13	C15	271	24.63
14	C16	287	26.11
15	C18	317	28.79
16	C20	344	31.26

APPENDIX B

TABLE B-1. PNA Chromatographic Data (FLO83224)

[hp] 5880A SAMPLER INJECTION @ 15:53 DEC 7, 1983
SAMPLE # : ID CODE :
1 SCOTT 83224
AREA %

RT	AREA	TYPE	WIDTH	HEIGHT	BASELINE
0.00			BASELINE @ START RUN = 8.27		
0.00			THRESHOLD @ START RUN = 1		
0.00			PEAK WIDTH @ START RUN = 0.02		
0.01			RP: EXTEND RT → ON		
4.650	131.14	BB	0.026	77.68	8.37
4.927	628.59	BB	0.028	357.72	8.39
5.071	12.99	BB	0.028	7.17	8.42
5.947	5069.02	BB	0.033	2422.61	8.44
6.505	4918.50	BB	0.036	2157.59	8.47
7.548	821.54	BB	0.041	310.21	8.45
8.663	924.63	BV	-----	289.70	8.47
8.730	1367.00	VV	-----	411.51	8.49
8.940	6429.57	VB	0.057	1753.28	8.53
9.647	4316.05	BB	0.058	1167.58	8.51
10.678	7693.96	BB	*-----	1581.29	8.53
12.350	605.51	BV	-----	99.24	8.44
12.579	6499.50	VB	/SYM	1191.61	8.47
12.837	760.83	BB	0.061	193.90	8.48
13.268	165.74	BB	0.068	38.29	8.41
14.574	1088.66	BB	0.077	220.23	8.40
15.170	365.72	BB	0.097	59.11	8.39
15.594	4759.76	BB	*-----	737.44	8.44
16.648	4302.72	BV	/SYM	553.65	8.37
16.765	1080.01	VV	-----	239.19	8.38
17.027	1592.11	VB	0.082	304.27	8.40
17.629	4377.26	BB	*-----	621.72	8.39
18.253	2050.56	BV	0.092	347.32	8.37
18.576	1940.24	VV	0.093	326.14	8.39
18.922	3260.59	VV	*0.103	497.95	8.42
19.070	19.37	VB	-----	4.29	8.43
20.642	7400.66	BB	*-----	779.76	8.70
23.098	13152.60	BV	*-----	1079.15	8.74
23.367	1498.05	VB	0.081	289.40	8.77
24.382	554.69	BV	0.086	101.35	8.77
24.646	521.14	VV	0.093	87.91	8.80
24.890	575.32	VB	0.084	107.50	8.82
25.584	1044.03	BV	0.091	179.18	8.82
25.762	194.12	VB	0.082	37.21	8.83
26.555	962.26	VB	0.093	162.53	8.89
26.931	44.32	BB	0.100	6.91	8.89
27.522	4655.02	BB	*-----	525.52	8.96
28.452	678.10	BV	0.091	116.71	8.95
28.605	39.95	VB	-----	8.03	8.97
28.886	15.48	BB	0.092	2.62	8.98

TABLE B-1: (continued)

29.441	2630.74	BV	*-----	328.08	9.00
29.597	778.05	VV	-----	146.40	9.01
29.749	115.35	VV	-----	16.94	9.01
30.003	128.74	VB	0.134	15.08	9.04
30.523	4820.08	BV	-----*	481.77	9.08
30.834	1144.72	VB	0.085	210.76	9.07
31.468	554.26	BB	0.088	98.23	9.06
31.862	40.84	BV	-----	8.26	9.07
31.984	135.06	VV	-----	23.59	9.07
32.275	120.65	VV	-----	21.00	9.07
32.451	211.24	VV	0.091	36.23	9.08
32.715	63.99	VB	0.094	10.70	9.08
33.127	972.40	BB	0.096	159.21	9.09
33.874	15.44	BV	-----	2.72	9.11
34.203	3901.97	VB	*-----	398.13	9.12
35.132	83.92	BB	*-----	11.52	9.13
35.623	8.91	VB	0.091	1.54	9.11
35.919	49.53	BB	0.090	8.64	9.14
36.272	25.17	BV	0.088	4.47	9.12
36.474	22.51	VV	0.091	3.88	9.14
36.778	145.25	VB	0.089	25.44	9.16
37.308	357.84	BV	0.158	35.43	9.16
37.595	14.51	VV	-----	2.42	9.17
37.700	12.95	VV	-----	2.19	9.17
38.042	809.13	VV	0.105	120.83	9.18
38.273	356.27	VV	0.092	60.85	9.19
38.483	25.70	VV	0.095	4.24	9.19
38.780	405.12	VV	0.094	67.82	9.20
39.121	482.86	VV	0.108	70.30	9.22
39.321	100.56	VV	-----	13.85	9.22
39.449	16.05	VV	-----	3.40	9.23
39.611	44.65	VV	-----*	6.18	9.23
39.803	21.53	VB	-----	3.94	9.24
40.366	347.51	BV	0.091	59.99	9.33
40.508	66.66	VV	-----	10.36	9.33
40.725	265.61	VV	0.086	48.56	9.33
41.205	18.20	VV	-----	3.03	9.35
41.533	1834.85	VV	-----	251.22	9.37
41.642	730.20	VV	-----*	132.43	9.37
41.919	24.06	VV	-----	5.05	9.39
42.009	27.54	VV	-----	5.77	9.39
42.137	86.46	VV	-----	16.78	9.40
42.262	43.09	VV	-----	8.78	9.40
42.630	244.45	VV	-----	47.15	9.42
42.757	318.48	VV	-----	66.66	9.42
43.092	41.59	VV	0.106	6.14	9.43
43.380	83.37	VV	-----	12.96	9.44
43.518	368.91	VV	0.085	68.16	9.45
44.052	575.93	VV	*0.094	95.94	9.47
44.232	25.71	VV	-----	4.98	9.48
44.717	43.93	VV	-----	8.92	9.50
44.845	188.65	VB	0.077	36.38	9.50
45.091	145.13	BV	0.080	28.44	9.54

TABLE B-1: (continued)

45.520	7.13	PB	-----	1.38	9.77
46.141	77.09	BE	0.076	7.65	9.78
46.495	766.96	BP	0.077	155.57	9.73
46.813	104.18	PV	0.094	17.34	9.58
47.090	41.32	VB	0.097	6.68	9.54
47.507	25.56	BP	0.073	5.49	9.52
47.870	72.66	BV	0.097	11.74	9.85
48.060	23.93	VV	-----	4.90	9.77
48.151	7.71	VV	-----	1.90	9.74
48.340	38.06	VV	0.078	7.61	9.66
48.485	38.93	VV	-----	6.22	9.60
48.888	21.68	PV	-----	4.88	9.49
49.075	131.36	VV	*-----	21.98	9.52
49.214	18.80	VV	-----	3.54	9.55
49.398	48.29	VV	0.13	5.73	9.53
49.827	100.68	BV	0.074	21.25	9.64
49.932	22.18	VV	-----	4.61	9.63
50.292	79.54	VV	-----*	11.21	9.59
50.486	18.57	VP	-----	4.17	9.58
50.730	7.87	PV	-----	1.06	9.60
50.834	6.95	VV	-----	1.68	9.63
50.965	19.43	VV	0.075	25.09	9.67
51.142	55.38	VB	0.071	12.26	9.73
51.647	170.06	BV	*0.092	29.09	9.47
51.827	6.24	VV	-----	1.43	9.47
51.917	9.19	VV	-----	1.67	9.48
52.065	30.43	VV	-----	6.75	9.48
52.215	50.09	VP	0.069	11.33	9.48
52.440	79.06	PV	0.083	14.95	9.52
52.720	11.88	VV	-----	2.12	9.60
52.978	61.95	VV	0.081	11.96	9.68
53.271	7.81	VB	-----	1.64	9.77
53.729	191.14	VV	0.070	42.77	9.73
53.853	21.80	VV	-----	5.09	9.70
54.092	19.00	VV	-----	4.08	9.64
54.793	5.42	BV	-----	1.15	9.59
54.957	10.30	VB	-----	1.69	9.75
55.228	167.41	BB	0.064	40.70	9.88
55.892	43.92	VV	-----*	7.70	9.67
56.233	5.84	PV	-----	1.44	9.59
56.761	3.58	BV	-----	0.87	9.79
56.840	4.86	VB	-----	1.24	9.86
57.053	31.86	BP	0.063	7.93	9.78
57.427	8.75	BV	-----	1.73	9.58
57.567	16.32	VV	-----	3.67	9.57
57.902	10.98	VV	-----	1.77	9.56
58.174	21.09	VV	0.096	3.43	9.54
58.452	7.88	VV	-----	1.35	9.53
58.645	13.10	VV	0.070	2.94	9.52
59.241	12.38	VB	0.092	2.12	9.50
59.495	7.32	BP	0.072	1.60	9.45
59.722	6.62	PB	0.067	1.54	9.33
59.992	15.18	BV	/SYM	2.20	9.32
60.203	7.46	VB	-----	1.30	9.32
60.474	6.74	BV	0.068	1.56	9.33

TABLE B-1: (continued)

50.670	9.01	VB	0.079	1.80	9.35
62.703	31.97	BB	0.083	3.75	9.18
72.357	15.60	BB	0.112	2.19	9.00
85.430	5.91	BB	-----	0.89	9.09
94.773	4.07	BB	-----	0.77	9.25
107.355	3.21	BB	-----	0.72	9.42
116.537	2.02	BB	-----	0.45	10.07
120.506	0.63	BB	-----	0.16	10.17
124.193	0.95	BB	-----	0.23	10.68

TOTAL AREA = 123559.00
MULTIPLIER = 1

REPORT DOCUMENTATION PAGE/PAGE DE DOCUMENTATION DE RAPPORT

REPORT/RAPPORT TR-FL-1 1a	REPORT/RAPPORT NRC No. 23408 1b
REPORT SECURITY CLASSIFICATION CLASSIFICATION DE SÉCURITÉ DE RAPPORT UNCLASSIFIED 2	DISTRIBUTION/DIFFUSION UNLIMITED 3

TITLE/SUBTITLE/TITRE/SOUS-TITRE (CLASSIFICATION)

4 Analysis of "Captain Scott's Antarctic Expedition 1910 Shell Motor Spirit" (UNCLASSIFIED)

AUTHOR(S)/AUTEUR(S)

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SERIES/SÉRIE

6 Internal Document

CORPORATE AUTHOR/PERFORMING AGENCY/AUTEUR D'ENTREPRISE/AGENCE D'EXÉCUTION

7 National Research Council
Division of Mechanical Engineering

SPONSORING AGENCY/AGENCE DE SUBVENTION

8

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1984/03 9	3663-2-4 10	3-09-030 11	(iii) 17 12a	12b	12c

NOTES

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DESCRIPTORS(KEY WORDS)/MOTS-CLÉS

14 Gas Chromatography, Mass Spectrometry, Proton Nuclear Magnetic Resonance.

SUMMARY/SOMMAIRE

15 A sample of motor gasoline taken from a recently discovered fuel dump in the Antarctica has been analyzed by various techniques to define its hydrocarbon composition.

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